



COORDINATING RESEARCH COUNCIL

**REAL WORLD VEHICLE EMISSIONS AND
EMISSIONS MODELING RESEARCH PROGRAM
OF THE
COORDINATING RESEARCH COUNCIL, INC.**

Timothy C. Belian and Brent K. Bailey

Coordinating Research Council, Inc.

Alpharetta, Georgia

10th CRC On-Road Vehicle Emissions Workshop

March 27-29, 2000

Hyatt Islandia Hotel

San Diego, CA

Updated 9/18/2000 by Bob Gorse, Ford, Vice-Chair RWES



COORDINATING RESEARCH COUNCIL

ABSTRACT

REAL WORLD VEHICLE EMISSIONS AND EMISSIONS MODELING RESEARCH
PROGRAM OF THE COORDINATING RESEARCH COUNCIL, INC.

Timothy C. Belian and Brent K. Bailey. Coordinating Research Council, Inc., Alpharetta,
Georgia

The Coordinating Research Council has served as the focal point for the automotive and petroleum industries in conducting cooperative research. Efforts have been directed at generating statistically valid data on the effects of fuels, lubricants, and vehicle systems on vehicle performance, emissions, and resultant air quality. Many research projects have also involved other entities including various government and industry organizations. Data and reports generated in CRC projects are made publicly available. During the past ten years, CRC has emphasized the importance of "real world" emissions measurements to obtain a better understanding of the emissions inventory and impacts on urban air quality. This program has been conducted under the auspices of the Real World Vehicle Emissions and Emissions Modeling Group of the CRC Emissions Committee. Related research on modeling urban air quality is conducted by the CRC Atmospheric Impacts Committee. An overview of this CRC research program will be presented including brief synopses of current projects such as "Diesel Particulate Sampling Methodology," "Effect of A/C on Tailpipe Emissions," "Remote Sensing of High Emitter Vehicles," "Biogenic Contribution to Urban Ozone and PM_{2.5}," and others.



COORDINATING RESEARCH COUNCIL

The Coordinating Research Council, Inc. (CRC) sustaining members are:

- * The U.S. Council for Automotive Research (USCAR)
- * The American Petroleum Institute (API)
- * Society of Automotive Engineers (SAE)

Its objective, as stated in the CRC Charter, is:

"To encourage and promote the arts and sciences by directing scientific cooperative research in developing the best possible combinations of fuels, lubricants, and the equipment in which they are used, and to afford means of cooperation with Government on matters of national interest within this field."

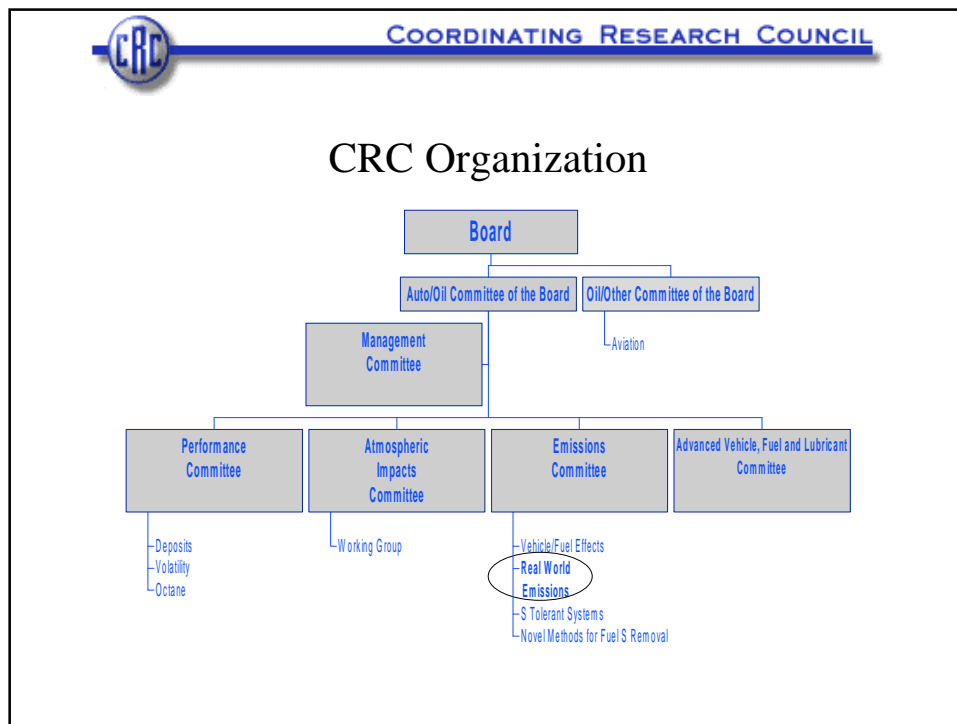


COORDINATING RESEARCH COUNCIL

CRC Research Committees

- CRC functions through committee action
- Industry and government participation
- Projects selected to meet cooperative goals
- Final reports are available to the public

“REAL WORLD VEHICLE EMISSIONS AND EMISSIONS
MODELING RESEARCH PROGRAM OF THE CRC” as presented by
Bob Gorse to the MSTRS on 10/11/00



The Real World Vehicle Emissions and Emissions Modeling Group of the CRC Emissions Committee

Frank S. Gerry, BPAmoco - Chair	David Lax, API
Robert A. Gorse, Ford - Vice-Chair	Jeff Long, CARB
Nick J. Barsic, John Deere	Hector Maldonado, CARB
Mike Bogdanoff, SCAQMD	Fred Minassian, SCAQMD
Steven Cadle, GM	Mani Natarajan, Marathon Ashland
Kevin Cullen, GM	Mike Nazemi, SCAQMD
King Eng, Equilon	Charles H. Schleyer, ExxonMobil
John Freil, Chevron	Shirish A. Shimpi, Cummins
Christine A. Gierczak, Ford	John Shipinski, Toyota
R. R. Graze, Caterpillar	Basil Ubanwa, TNRCC
Albert M. Hochhauser, ExxonMobil	Jim Uihlein, ARCO
Douglas R. Lawson, NREL	Steve Welstand, Chevron



COORDINATING RESEARCH COUNCIL

Current Projects in the Real World Vehicle Emissions and Emission Modeling Group

<u>Project No.</u>	<u>Project Name</u>	<u>Project Status</u>
• E-23	Remote Sensing of High Exhaust Emitters	Annual reports available
• E-37	Effect of A/C on Regulated Emissions	Report 3Q, 2000
• E-39	EMFAC7G/EMFAC2000 Analysis	Report 2Q, 2000
• E-41	Evaporative Emissions of Newer Vehicles	Project Complete
• E-43	Diesel Particulate Sampling Methodology	Report 3Q, 2001
• E-52	On-Road Ammonia Emissions	Report 2Q, 2000
• E-53	Vehicle Analysis--Weekday vs. Weekend	Report 1Q, 2001
• E-54	Central Carolina Vehicle PM Study	Report 2Q, 2000
• E-55	NOx and PM Emissions from HD Diesel	Start 3Q, 2000
• E-56	Diesel NOx and PM Remote Sensing	Start 3Q, 2000
• E-58	Carboxylic Acid and Carbonyl Emissions	Report 2Q, 2000
• E-59	Diesel Gasoline PM Split	Start 3Q, 2000



COORDINATING RESEARCH COUNCIL

CRC Project No. E-23: Remote Sensing of High Exhaust Emitters

- **Objectives:** To follow emission rates determined by remote sensing measurements of on-road light-duty vehicles at selected sites to identify trends over a five-year period and to estimate changes in high-emitter vehicle populations.
- **Findings/Status:**
 - * Past studies show that 50(80)% of emissions come from 10(20)% of vehicles
 - * Project in cooperation with EPA, CARB, and Georgia Tech
 - * Los Angeles, Phoenix, Denver, Chicago, Raleigh-Durham, Atlanta
 - * The University of Denver under contract to CRC
 - * A data collection protocol standard has been established
 - * The project continues until Q2, 2004 ?Extend to 2-yr Interval?
 - * See the CRC website for annual reports



COORDINATING RESEARCH COUNCIL

CRC Project No. E-37: Effect of A/C on Regulated Emissions

- **Objectives:** To measure regulated emissions from selected in-use vehicles under a variety of environmental conditions, with and without the vehicle air conditioner operating.
- **Findings/Status:**
 - * CAVTC project: Support from CARB and TNRCC
 - * Phase 1 study completed in 1999 on initial vehicle fleet
 - * Phase 2 study extended vehicle fleet and test conditions
 - * Temperature, humidity, solar load, and AC variables
 - * Effects of total AC load (enthalpy) explored
 - * Statistical analysis conducted on all data
 - * Final report & SAE paper to be prepared 3Q, 2000



COORDINATING RESEARCH COUNCIL

CRC Project No. E-39: EMFAC7G/EMFAC2000 Analysis

- **Objectives:** To estimate the uncertainties in the EMFAC model and recommend corrective actions to reduce uncertainties.
- **Findings/Status:**
 - * CARB cooperation in the evaluation by ENVIRON
 - * Comprehensive EMFAC7G evaluation on 12 model elements
 - * Final Report on EMFAC7G completed March 1999
 - * EMFAC2000 review to be conducted
 - * Model results compared against tunnel study



COORDINATING RESEARCH COUNCIL

CRC Project No. E-41: Evaporative Emissions of Newer Vehicles

- **Objectives:** To perform evaporative emissions testing of a significant sample of newer LDVs (1992 to 1997) in a manner consistent with previous CRC evaporative emissions studies (E-9 and E-34) and A/O Hot Soak Pilot Study.
- **Findings/Status:**
 - * ATL conducted the vehicle test program
 - * Sierra prepared Final Data Analysis Report (October 1999)
 - * Hot soak, running loss, and real-time diurnal emissions measured
 - * Enhanced Evaporative Controls show significant reductions
 - * MOBILE5b and MVEI7G model overpredictions in some cases



COORDINATING RESEARCH COUNCIL

CRC Project No. E-43: Diesel Particulate Sampling Methodology

- **Objectives:** To determine the actual size distributions and particle count in exhaust plumes on the road from heavy-duty diesel vehicles and compare that data to the size distributions and particle counts found in test facilities.
- **Findings/Status:**
 - * Sponsor Team: DOE/NREL, EMA, Cummins, Caterpillar, SCAQMD, CARB, Volvo, NIOSH
 - * Project Team: UMN, WVU, Paul Scherrer Institute, CMU, DRI, Tampere University, UC Davis
 - * Mobile Laboratory constructed
 - * Cummins field study and Langley AFB wind tunnel study completed
 - * Cummins laboratory and Caterpillar field and laboratory tests almost completed
 - * Sample dilution process and temperature affects nucleation mode particle distribution



COORDINATING RESEARCH COUNCIL

CRC Project No. E-52: On-Road Ammonia Emissions

- **Objectives:** To sample the rate of ammonia and ammonium ion emission levels from on-highway vehicles.
- **Findings/Status:**
 - * DRI sampled vehicles in the Tuscarora Mountain Tunnel (hot 55 mph steady state, newer fleet)
 - * Ammonia analysis conducted by UC Davis
 - * Final report out for approval
 - * Results compared to other estimates:
 - LDSI 15 mg/mi; HDD <8.4 mg/mi
 - LDSI 116 mg/mi (Cass, Van Nuys Tunnel)
 - LDSI 113 mg/mi (Sutton, Europe)
 - LDSI 7.9 mg/mi (Cadle, Oxidation Catalyst, 1980)



COORDINATING RESEARCH COUNCIL

CRC Project No. E-53: Weekday/Weekend Ozone Observations in the SoCAB

- **Objectives:** To use methods that can test several hypotheses regarding the causes of high weekend ozone in the South Coast Air Basin. Hypotheses include spatial and temporal differences, changes in VOC/NOx ratios, weekend evening emissions carryover, and others.
- **Findings/Status:**
 - * DOE/NREL-sponsored analysis and field program
 - * DRI is doing retrospective analysis; September 2000 field study
 - * CRC task on "Update and Improve Source Composition Profiles"
 - * 40 canister and DNPH VOC source samples to be collected
 - * Conducting monitoring near epicenter of non-mobile VOC sources



COORDINATING RESEARCH COUNCIL

CRC Project No.E-54: Central Carolina Vehicle PM Study

- **Objectives:** To measure exhaust PM_{10} and $PM_{2.5}$ emission rates from in-use LDVs in the eastern U.S. and to create a database that can be used to develop a source profile for these emissions for use in receptor modeling.
- **Findings/Status:**
 - * EPA conducted the vehicle test program, Cadle doing SAE paper
 - * Winter and summer test phases (outdoor dynamometer)
 - * CRC/NREL sponsored chemical analysis of PM by DRI
 - * Gasoline LDV PM emission rates similar to other studies
 - * Good correlation between PM_{10} and $PM_{2.5}$ emission rates
 - * 80% of total carbon is present as "organic carbon"
 - * PAH speciation available for creation of profiles



COORDINATING RESEARCH COUNCIL

CRC Project No.E-55: NO_x and PM Emissions from HD Diesel

- **Objectives:** To use novel approaches to validate or verify the accuracy of diesel emissions inventories for NO_x and PM in California's South Coast Air Basin by improving NO_x and PM emission factors, which will then be compared with current diesel emission factors in the inventory models.
- **Findings/Status:**
 - * Cooperative sponsors: CARB, DOE/NREL, SCAQMD, EPA('01) and EMA
 - * Diesels considered major source of PM and NO_x
 - * PM and NO_x health concerns
 - * Current emission factors uncertain
 - * Statistical analysis underway to identify project scope
 - * To be jointly conducted with CRC Project No. E-59



COORDINATING RESEARCH COUNCIL

CRC Project No. E-56: Remote Sensing
Measurements of On-Road Heavy-Duty Diesel NO_x
and PM Emissions

- **Objectives:** Develop remote sensing systems to measure NO and PM and demonstrate the application of developed techniques on a variety of heavy-duty vehicles and vocations.
- **Findings/Status:**
 - * Collaborative effort to complement CRC Project No. E-55
 - * RFP issued by CRC in Q2, 2000
 - * Validation of the remote sensing measurements required
 - 4Q'00 shootout between two bidders for demonstration/validation
 - * Characterization of bus fleets, short- and long-haul trucks, and others
 - * Recommendations on future HD remote sensing applications



COORDINATING RESEARCH COUNCIL

CRC Project No. E-58: On-Road Emissions of
Carboxylic Acids and Carbonyls

- **Objectives:** To measure on-road vehicle emission rates of several carboxylic acids and carbonyls
- **Findings/Status:**
 - * Project conducted by DGA, Inc.
 - * Carbonyl samples collected in the 1999 Tuscarora Mountain Tunnel study
 - * Carboxylic acid samples collected in the 1999 Caldecott Tunnel study
 - * Emission factors for HD and LD will be calculated
 - * Final Report Part 1 updated draft received; Part 2 to be combined with Part 1



COORDINATING RESEARCH COUNCIL

CRC Project No. E-59: Diesel Gasoline PM Split

- **Objectives:** To determine the apportionment of mobile source PM between gasoline and diesel vehicles with statistical significance assigned to each source.
- **Findings/Status:**
 - * Cooperative CRC, DOE/NREL, CARB project
 - * Prior data undergoing statistical analysis to determine project scope
 - * Review previous receptor model studies in Los Angeles and Denver
 - * To be jointly conducted with CRC Project E-55



COORDINATING RESEARCH COUNCIL

CRC Emissions Committee

AMMONIA EMISSIONS RESPONSE TO FUEL SULFUR (E60) (CY 2000 budget \$300k and CY 2001 budget \$300k)

- Supplement the inventory data on fleet ammonia emissions from LEVs and determine emission response to three fuel sulfur levels
- Vehicles from rental fleet, as-received and aged catalysts, 3 test fuels, FTP and US06 drive cycles
- Anticipate RFP next month

LUBRICANT SULFUR EFFECTS ON LEV EMISSIONS (E61) (CY 2000 budget \$300k and CY 2001 budget \$200k)

- Quantify emission impact from varying sulfur levels in base oil and ZDP additives on LEVs operated with sulfur free gasoline
- Scoping study, need to determine if statistical difference can be found.
- Combination with E-60 to reduce program costs

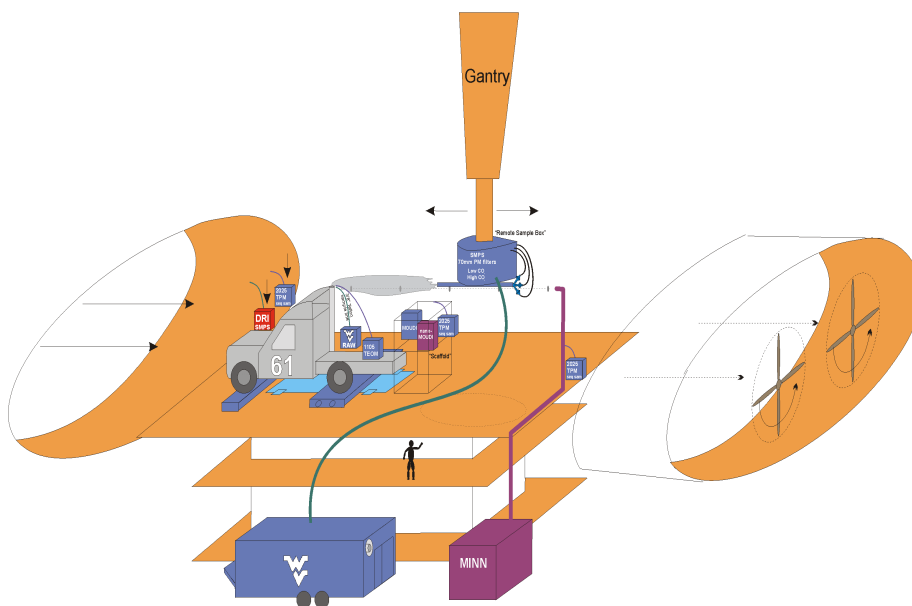


COORDINATING RESEARCH COUNCIL

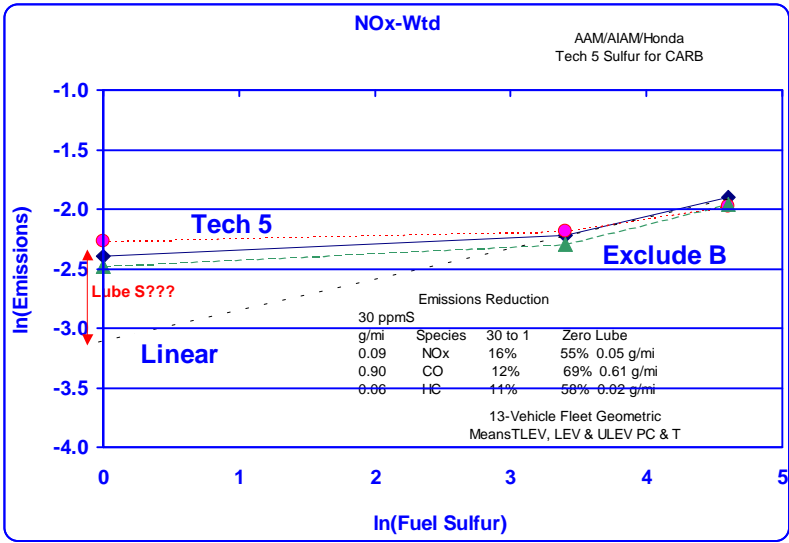
Summary

1. CRC works cooperatively with industry and government to support a variety of research efforts including those related to the environmental impacts of vehicle emissions to provide statistically valid objective data, which are publicly available.
2. The CRC Real World Vehicle Emissions and Emissions Modeling Group conducts research to investigate the emission rates of in-use vehicles and estimate the impact of real-world vehicles on the emissions inventory.
3. The CRC Atmospheric Impacts Committee conducts studies to predict the impact of emissions on air quality and airborne toxics.

Wind Tunnel Layout



This illustration shows a typical application of the University
of Minnesota Mobile Aerosol laboratory developed for the
CRC E-43 Program





COORDINATING RESEARCH COUNCIL

CRC Web Site
www.crcao.com